X-ray microscopy at BESSY: From nano-tomography to fs- imaging

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Among many scientific questions in life sciences, the cell nucleus is still a mystery. How the DNA and its associated proteins are arranged and packaged to fit within this ~10 µm diameter organelle is unknown. Fluorescence images are diffraction-limited to ~200 nm, whereas current x-ray imaging can achieve a ten-fold improvement in resolution, namely ~20 nm. Since fluorescence and x-ray microscopy permit analysis of whole cells, it is possible to investigate the same cell in both microscopes. These correlative studies are ideally suited to x-ray microscopy because of its ability to image cells in 3D. We expect that correlative 3D fluorescence and x-ray microscopy, as applied to nuclear structure, will yield significant new insights.

Another application field for x-ray microscopy which is of fundamental interest in materials science is electromigration in advanced copper interconnects buried in low-k dielectric materials. Quantitative time- resolved x-ray microscopy mass transport studies of the early stages of electromigration in an inlaid copper line/via structure show that void formation is a highly dynamic process. Future work will be based on time-resolved x-ray tomography to determine the exact location of void nucleation and migration as well as to measure quantitatively the mass transport in the volume.

To further improve 3D x-ray imaging towards sub-10 nm spatial resolution and to increase the usable photon energy range by phase contrast methods, progress has to be made in x-ray optics, instrumentation and theory. In the talk, the current status and future aspects of x-ray microscopy at 3rd generation electron storage rings and the upcoming Free Electron Lasers with their fs-pulses will be discussed.